Erasable, reusable optical rec rding elements and methods f r erasing such el

Patent number: EP0163397
Publication date: 1985-12-04
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Classification:
- international: G11B7/24; G11B7/00
- european: G11B7/24B5P
Application number: EP19850302602 19850415
Priority number(s): US19840600714 19840416

Also publishe

- US452
- JP602
- EP016

Cited docum

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- US424
- US438
- JP591

Abstract not available for EP0163397
Abstract of correspondent: **US4527173**
An erasable, reusable recording element comprising a support having thereon a heat-deformable optical recording layer having a transparent overcoat is disclosed.

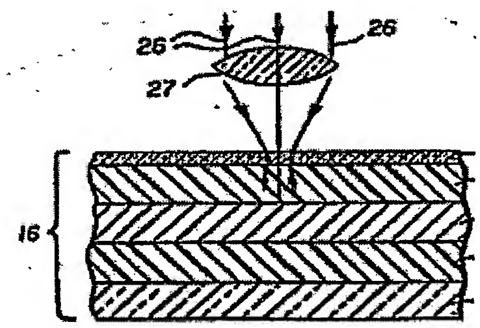

FIG. 2

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publicati n number: **0 163 397 B1**

(12) EUROPEAN PATENT SPECIFICATION

(45) Date of publication of patent specification: 25.10.89

(51) Int. Cl.^{4}: **G 11 B 7/24**, G 11 B 7/00

(21) Application number: 85302602.9

(22) Date of filing: 15.04.85

(54) Erasable, reusable optical recording elements and methods for erasing such elements.

(30) Priority: 16.04.84 US 600714

(43) Date of publication of application: 04.12.85 Bulletin 85/49

(45) Publication of the grant of the patent: 25.10.89 Bulletin 89/43

(84) Designated Contracting States: DE FR GB NL

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EP 0 163 397 B1

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Description

This invention relates to erasable, reusable optical recording elements, particularly optical recording elements and a method for erasing such elements.

Recording elements in which information is recorded by thermally deforming an optical recording layer are known. Such elements are useful in rapidly recording large amounts of digital information in a small area. These elements are also useful in recording video information.

Recording on an optical recording element is accomplished by an information modulated beam of high energy density radiation such as a laser beam. The laser beam is focused onto the surface of the optical recording layer of the element. The recording layer absorbs energy from the laser so that a small portion of the layer is deformed thereby forming an information bearing record element. The deformations may be in the form of pits, holes or other changes in the material. This technique of optical recording on a heat-deformable recording layer is usually referred to in the optical recording art as "ablative recording".

Generally, there is continuous relative motion between the laser beam and the layer so that as the laser is pulse modulated, discrete deformations of varying sizes are created in the layer. The sizes and spacing of these deformations constitute the encoded information. A variety of materials has been proposed for use for the heat-deformable recording layer.

It is known to protect optical recording layers with overcoats. U.S. Patent 4,069,487 disclosed protective overcoats having a thickness of from 0.15 μm to 10 μm.

Recording elements having an amorphous optical recording layer comprising a dye and a binder are disclosed in U.S. Patent 4,380,769. This element stores the information in the form of heat deformations in information tracks. This element can be erased by applying heat uniformly over the surface to smooth out the information tracks. Erasures cannot be carried out on such elements selectively, track by track or on portions of such tracks.

It is the object of the present invention to provide recording elements having optical recording layers which can be erased selectively track by track or portions of such tracks.

The foregoing object is accomplished by providing a novel erasable, reusable recording element comprising a support having thereon a deformable amorphous optical recording layer of a dye with a binder characterized in that the layer has a ceramic overcoat having a thickness greater than 0.05 μm and not more than 0.3 μm.

The invention also provides a method of erasing an optical recording element of the invention comprising the steps of:

providing an information bearing record element in which the information is encoded in information tracks in the form of heat deformations in the heat-deformed optical recording layer; and

applying sufficient heat to the information record element to smooth out the heat deformations forming the information tracks wherein the heat is applied by selectively focusing one or more beams of high energy density radiation, which is absorbed by the optical recording layer, on the particular information track(s) or portion of track(s) to accomplish at least partial erasure.

Figure 1 shows a schematic apparatus for recording, reading back information and erasure on the recording elements of the invention. Figures 2 and 3 show a cross section of a recording element of the invention before and after recording respectively.

Useful recording elements are disclosed in U.S. Patent 4,380,769. Such recording elements comprise a support having thereon an optical recording layer that is an amorphous layer of a dye and a binder. Such layers having an absorption factor of at least 20 at a first wavelength and being substantially transparent at a second wavelength are particularly useful. Layers having this level of absorption factor are capable of being thermally deformed by a beam of high energy density radiation of the first wavelength to form a deformation comprising a hole or depression.

The "absorption factor" of the amorphous material is defined as the product of the weight fraction of dye included in the amorphous material and the molar extinction coefficient of the dye at the wavelength of the recording beam of choice, divided by the molecular weight of the dye (MW), and having the units of liter per gm-cm.

Other useful layers are disclosed in U.S. Patent 4,415,621 granted to Specht et al, November 15, 1983; U.S. Patent 4,446,223 and U.S. Patent 4,499,165.

Useful ceramic materials include aluminum oxide, silicon monoxide, SiO, silicon dioxide, SiO_2, silica glass such as Schott-Glass® (available from Schott Glass Company), quartz and magnesium fluoride (MgF_2).

Figure 1 shows schematically an apparatus for making the information bearing record element used in the erasure method of this invention. The apparatus is also used for playing back the information therefrom. Recording Element 16 comprises, as shown in Figure 2, an overcoat layer 41, heat-deformable amorphous optical recording layer 42 reflecting layer 43 surface smoothing layer 44 and substrate 45.

The optical recording layer 42 preferably has a very high optical density, i.e., an absorption factor f 20 or great r at the wavelength of th recording beam f choice, in order t be able to absorb sufficient energy from the rec rding beam t und rgo proper thermal deformation.

As depict d in Figure 1 in r sponse to a drive signal, the int nsity of a recording laser beam 10 is modulated in accordance with information to be recorded on recording Element 16. The modulated laser

beam is collect d by a lens 14 and collimated by a lens 18 and is directed by means of mirror Elements 20, 23 and 24 to a high numerical aperture lens 26 which focuses the modulated laser beam to a recording spot on the recording Element 16.

During recording, the recording Element 16 is spun at a constant rate, e.g., 1800 rotations per minute (rpm). As a result, a track of encoded information 30, in the form of heat deformations, is recorded on the optical recording layer and recording Element 16 resulting in an information bearing record element. As recording continues, the recording spot 28 is caused (by means not shown) to scan radially inward across the recording Element 16, thereby causing information deformations to be recorded along a spiral track that extends from an outer radius R_o to an inner radius R_i. The sizes and spacings of the recorded deformations vary in accordance with the information contest of the recording laser drive signal, as well as with radial position on the recording Element 16.

When the recordings are carried out the optical layer deforms to form pits. The pits in this embodiment represent the recorded information. Figure 3 is a cross section of recording Element 16 after information has been recorded showing a pit 46 and an associated dome 47. The dome is formed in the overcoat during pit formation.

During the readback process, the now information bearing record Element 16 is spun at the same rate as it was spun during the recording process. A laser beam 22 from a readout laser is expanded in diameter by means of lenses 34 and 36. A diode laser could also be used for readout. The optical path of the readout laser beam is folded by a beam splitter 21 and mirrors 23 and 24 so that the readout laser beam is focused to a playback spot on the recording element 16 by the high numerical aperture lens 26. The recording disk 16 is assumed to be of the reflective type so that the radiation forming the playback spot is reflected back through the high numerical aperture lens 26 after interacting with the information marks recorded on the optical element 16. (In the case of a transmissive optical element, the playback optical system would be arranged so that the playback spot would pass through the optical disk in order to interact with recorded information marks.) A lens 38 directs reflected laser radiation which has been diverted by the prism beamsplitter onto a detector 40 which produces an electrical playback signal in response to temporal variations in the irradiance of the reflected laser radiation falling on the detector.

In the method of this invention the overcoated information bearing element produced by the above described recording process is erased by subjecting selected information tracks thereof to a laser beam as described above in the recording or playback process. This erasure beam may be unmodulated or modulated at a frequency high enough to cause adjacent beam exposure spots to overlap to a large extent thereby producing a quasi-continuous exposure. The laser beam radiated is absorbed by the recording layer creating heat which causes the information track upon which the laser beam is focused to smooth out as described below. The erase laser beam can be the same beam used during the recording process.

Overcoats are essential to the erasure method of this invention. First, the overcoats prevent loss of the material ablated during the recording process. This is important since erasure and re-recording involves smoothing out ablated pits by refilling the pits with the original recording layer composition.

Secondly, the overcoats provide stress that opposes the pushing of the recording layer material into the pit rims during recordings. The same stress forces the material back toward the pit centers during the erasure exposure. Electron micrographs have shown that thin overcoats up to about 0.05 µm tend to form dome-like structures situated over the pits which trap the material ablated from the recording layer to form pits during the recording process. In Figure 3, a dome 47 is shown. The heated material solidifies in the rim around the pit. During the erasure exposure, the material trapped in the pit rims is reheated by absorbing energy from the laser beam. This reheating causes the ablated material to become plastic. The stress produced by the overcoat causes the reheated plastic ablated material to flow back into the pit.

Thicker overcoats (above about 0.05 µm) also trap material ablated from recording layers. They provide more opposition to pit formation and form shallower domes during the recording process. This leads to less well defined pits but allows for more rapid erasure, i.e., fewer revolutions or passes through the laser spot.

It is clear therefore that with sufficient laser power, erasure can be accomplished with overcoats of almost any thickness. Choosing an appropriate overcoat thickness for a given application is a trade-off between pit sharpness and ease of erasure, with thin overcoats favoring the former and thick overcoats favoring the latter.

Readbacks carried out after a single erasure cycle (i.e., one pass of a pit through the unmodulated laser spot) show a reduced CNR (carrier-to-noise ratio) compared to the CNR of the original information bearing record element. Multiple erasure cycles reduces CNR further. By moving the laser beam slightly so that its spot is focused on the inner or outer rims of the pits as they move through the spot, additional material is caused to flow back into the pits and the readout carrier-to-noise ratio is reduced further. By using this technique with overcoated recording elements having heat-deformable optical recording layers, one is able to reduce the readout signals of selected information tracks, or portions thereof, so that they cannot be detected above th noise level of the rec rding element. This is referred to as complete erasur .

However, complete erasure is n t r quired for a practical system because the readback electronics can be designed to resp nd only t signals having a magnitud exceeding a certain threshold. When a new signal is r corded on a previously rased track, it has been demonstrated that in some applicati ns n interference from th previous recording can b observed.

The preferred overcoats have thicknesses in the range of 0.05 µm up to 0.1 µm. For erasure purposes overcoat thicknesses up to 0.3 µm are also useful. Above 0.3 µm the power needed to erase becomes impractical for commercial recording instruments.

The erasure method of this invention can be optimized further by optically tailoring the laser beam spot to have one high intensity region on one edge of the track, another high intensity region on the other edge of the track and a lower intensity region in the center of the track. Of course, the same result could be obtained by using two different lasers and focusing each laser spot on a different edge of the track through one lens system.

The method can be further optimized by elongation of the laser erase spot in the intrack direction to provide a longer exposure time. This will permit erasure in some cases in a single revolution. This elongation could be accomplished optically or by using additional lasers having their focused spots offset.

After a selected information track has been erased, as described above, other high quality recordings can be made in the erased information tracks. The CNR obtained is similar to the CNR obtained on the original blank overcoated recording element. That CNR is achieved with the same laser power as used in the initial recording. This demonstrates an erasable, reusable system.

The ceramic overcoated record element is capable of many record/erase/record cycles.

The following examples will illustrate the invention further.

Two different recording elements were prepared and used in testing the method of this invention. Each was prepared as follows. A 300 mm diameter circular glass substrate was spin-coated with a surface-smoothing composition by flooding the glass substrate with the smoothing composition at low rpm (about 80—100 rpm) and then leveling the coating by advancing the speed to about 500 rpm. The surface-smoothing composition comprised:

pentaerythritol tetraacrylate	20 g
a low-viscosity urethane-acrylate monomer (UV-curable Topcoat 874—C—2002™ Fuller O'Brien Corp.)	20 g
2-ethoxyethanol	60 g
a coumarin sensitizer composition	3 g
surfactant	3 drops

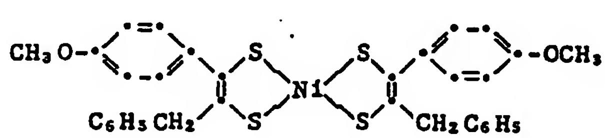
The coated and dried surface-smoothing composition was cured by irradiating with a 3000 watt pulsed xenon arc lamp at 46 cm (18 inches) for 4 minutes.

The thus smoothed surface of the substrate was then coated with a 0.05 µm thick reflecting layer of aluminum by vapor deposition.

Coating compositions comprising a 1:1 mixture of a dye, or a mixture of dyes, and a binder dissolved in bromobenzene were prepared. The coating composition were spin coated on the reflecting layer at a low rpm and then leveled at about 1300 rpm.

Using the above procedure, two different recording elements were prepared which were identical except for the optical recording layers. The dye and binder for each of the two elements were as follows:

Optical recording Element 1 was a 1:1 mixture of dye and binder. The dye was itself a 1:1 mixture of



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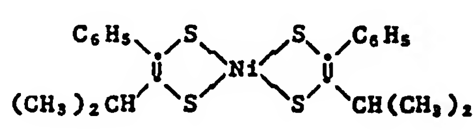
and



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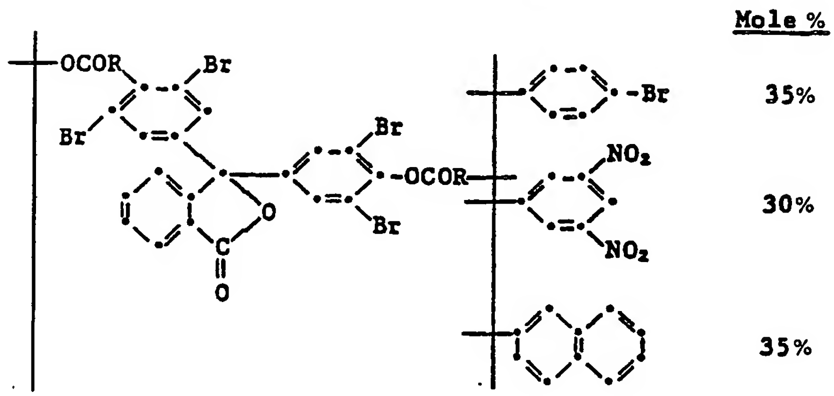
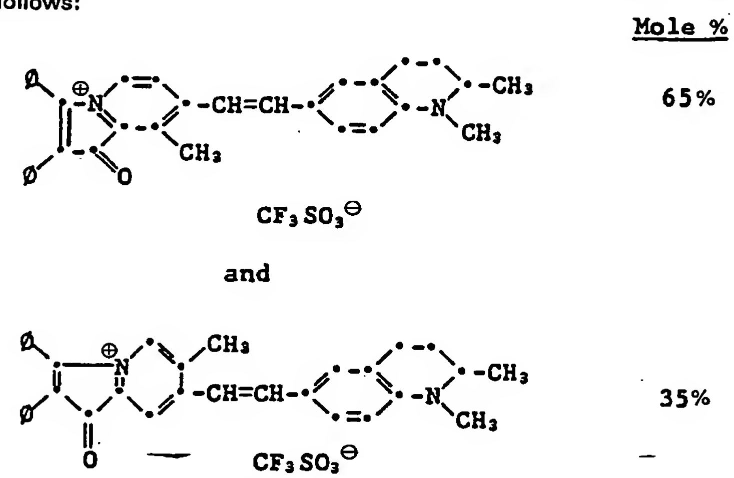
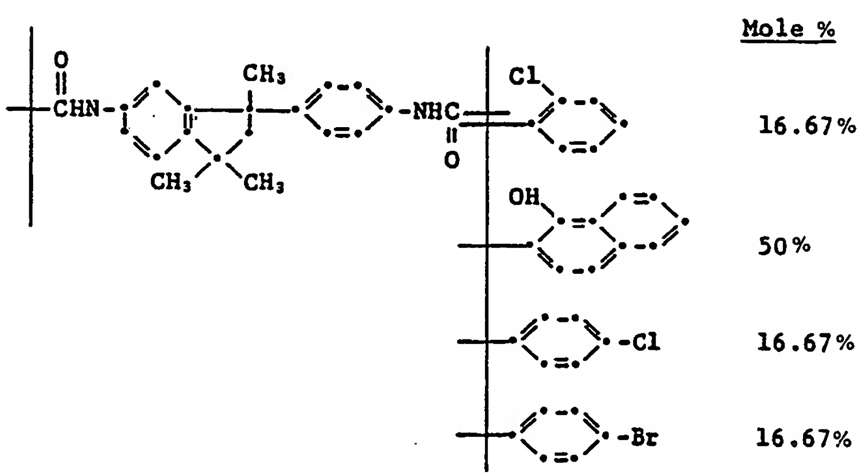
The binder used was a mixed compound represented by the structure:



Optical recording Element 2 was also a 1:1 mixture of two dyes and binder. The dye was a mixture of two isomers as follows:



The binder was a mixed compound represented by the structure:



After drying, the r cording elements were overcoated with a Schott-Glass available from the Schott Glass Company. Ov rc ating of the element was carried out by vacuum deposition.

Example 1

The record/erase/record cycle described herein was carried out 3500 times on a 0.3 μm Schott-Glass overcoated Element No. 1. Carrier-to-noise ratio of 50 decibels (8.8 MHz carrier, 30 KHz bandwidth, element speed 19 m/sec) was obtained at the final recording.

Example 2

The record/erase/record cycle was carried out on 0.3 μm Schott-Glass overcoated Elements 1 and 2. After the first recording, the elements had a CNR of 50 decibels. This CNR was reduced to only 20 decibels when subjected to three revolutions through the laser erase spot. The 50 decibel CNR was reproduced upon re-recording each element.

Example 3

The record/erase/record cycle was carried out on both Elements 1 and 2 with 0.01 μm and 0.05 μm Schott-Glass overcoats. Each of the prepared elements were found to be erasable on a selective basis, track by track, when subjected to the erasure process described hereinbefore. Re-recording results were similar to those obtained on the original blank recording element.

Claims

1. An erasable, reusable recording element 16 comprising a support 45 having thereon an optical recording layer 42 comprising a deformable amorphous layer of a dye and a binder characterized in that the recording layer has a transparent ceramic overcoat 41 having a thickness greater than 0.05 μm and not more than 0.3 μm.

2. The element of claim 1 wherein the recording layer 42 has an absorption factor of at least about 20 at a first wavelength and is substantially transparent at a second wavelength.

3. The element of claim 1 or claim 2 wherein the support 45 has thereon the following layers in the following order:

a) a smoothing layer 44;
b) a metal reflection layer 43;
c) the optical recording layer 42; and
d) the transparent ceramic overcoat 41.

4. The element of claim 1, 2 or 3 wherein the overcoat is glass.

5. The element of claim 1, 2 or 3 wherein the overcoat is Schott-Glass.

6. The element of claim 1, 2 or 3 wherein the overcoat material is selected from the group consisting of SiO_2, MgF_2, SiO, quartz, silica and glass.

7. A method of erasing an optical recording element comprising the steps of:

providing an information bearing record element 16 in which the information is encoded in information tracks in the form of heat deformations 46 in a heat-deformed optical recording layer 42; and

applying sufficient heat to the information record element to smooth out the heat deformations 46 forming the information tracks;

characterized in that the optical recording element is an element according to any one of the preceding claims; and

the heat is applied by selectively focusing one or more beams of high energy density radiation, which is absorbed by the optical recording layer, on the particular information track(s) or portion of track(s) to accomplish at least partial erasure.

8. The method of claim 7 wherein the beam of high energy density radiation is a laser beam which is first focused on one edge of the information track and then on the other edge of the information track to smooth out the heat deformations making up the track.

9. The method of claim 8 wherein a single laser beam is tailored optically to have a high intensity region at each edge of the information track(s).

10. The method of claim 7 wherein a laser beam spot is focused on one edge of the information track and another laser beam spot is focused on the other edge of the information track.

11. The method of claim 7 wherein the selected information track or portions thereof is subjected to multiple exposures of the laser beam in order to smooth out the heat deformations making up the information track.

12. The method of claim 7 wherein the laser beam spot is elongated in the direction of the selected information track.

Patentansprüche

1. Löschbares, wiederverw ndbares Aufzeichnungsel ment 16 mit einem Träger 45, auf den eine optische Aufzeichnungsschicht 42 mit einer def rmierbaren amorphen Schicht aus einem Farbst ff und einem Bindemittel aufgetragen ist, dadurch g kennzeichnet, daß die Aufz ichungsschicht eine transparente keramische Überzugsschicht 41 mit ein r Dick von größer als 0,05 μm and nicht mehr als 0,3 μm aufweist.

2. Element nach Anspruch 1, in dem die Aufzeichnungsschicht 42 bei einer ersten Wellenlänge einen Absorptionsfaktor von mindestens etwa 20 aufweist und bei einer zweiten Wellenlänge praktisch transparent ist.

3. Element nach Anspruch 1 oder 2, in dem der Träger 45 die folgenden Schichten in der folgenden Reihenfolge aufweist:
a) eine glättende Schicht 44;
b) eine Metallreflexionsschicht 43;
c) die optische Aufzeichnungsschicht 42 und
d) die transparente keramische Überzugsschicht 41.

4. Element nach Anspruch 1, 2 oder 3, in dem die Überzugsschicht aus Glas besteht.

5. Element nach Anspruch 1, 2 oder 3, in dem die Überzugsschicht aus Schott-Glas besteht.

6. Element nach Anspruch 1, 2 oder 3, in dem das Überzugsschichtmaterial aus der Gruppe folgender Materialien ausgewählt ist: SiO_2, MgF_2, SiO, Quarz, Kieselerde und Glas.

7. Verfahren zum Löschen eines optischen Aufzeichnungselementes mit folgenden Verfahrensstufen:
Bereitstellung eines Informationen aufweisenden Aufzeichnungselementes 16, in dem die Informationen in Informationsspuren in Form von Wärmedeformationen 46 in einer durch Wärme deformierten optischen Aufzeichnungsschicht 42 kodiert sind; und
Zuführen einer ausreichenden Wärmemenge zu dem Informationen-Aufzeichnungselement zum Zwecke der Ausglättung der Wärmedeformationen 46, die die Informationsspuren bilden;
dadurch gekennzeichnet, daß man als optisches Aufzeichnungselement ein Element nach einem der vorstehenden Ansprüche verwendet und daß die Warme durch selektive Fokussierung von einem oder mehreren Strahlen einer Strahlung hoher Energiedichte zugeführt wird, die durch die optische Aufzeichungsschicht an der speziellen Informationsspur(en) oder Teilen der Informationsspur(en) absorbiert wird, um mindestens eine teilweise Löschung herbeizuführen.

8. Verfahren nach Anspruch 7, in dem der Strahl einer Strahlung hoher Energiedichte ein Laserstrahl ist, der zunächst auf einen Rand der Informationsspur und dann auf den anderen Rand der Informationsspur fokussiert wird, um die Wärmedeformationen, die die Spur bilden, auszuglätten.

9. Verfahren nach Anspruch 8, in dem ein einzelner Laserstrahl optisch derart zugeschnitten wird, daß er einen Bereich hoher Intensität an jedem Rand der Informationsspur(en) aufweist.

10. Verfahren nach Anspruch 7, in dem ein Laserstrahlspot auf einen Rand der Informationsspur und ein anderer Laserstrahlspot auf den anderen Rand der Informationsspur fokussiert wird.

11. Verfahren nach Anspruch 7, in dem die ausgewählte Informationsspur oder Teile hiervon mehrfachen Exponierungen durch den Laserstrahl ausgesetzt werden, un die Wärmedeformationen, die die Informationsspur bilden, auszuglätten.

12. Verfahren nach Anspruch 7, in dem der Laserstrahlspot in die Richtung der ausgewählten Informationsspur verlängert wird.

Revendications

1. Elément d'enregistrement optique 16 effaçable, réutilisable comprenant un support 45 recouvert d'une couche d'enregistrement optique 42 comprenant une couche amorphe déformable contenant un colorant et un liant, caractérisé en ce que la couche d'enregistrement porte une surcouche de céramique transparente 41 ayant une épaisseur supérieure à 0,05 µm et ne dépassant pas 0,3 µm.

2. Elément selon la revendication 1 dans lequel la couche d'enregistrement 42 a un facteur d'absorption d'au moins 20 à la première longueur d'onde et est pratiquement transparente à la seconde longueur d'onde.

3. Elément selon la revendication 1 ou 2 dans lequel le support 45 porte dans l'ordre les couches suivantes:
a) une couche de lissage 44;
b) une couche réfléchissante métallique 43;
c) une couche d'enregistrement optique 42; et
d) une surcouche de céramique transparente 41.

4. Elément selon les revendications 1, 2 ou 3 dans lequel le surcouche est en verre.

5. Elément selon les revendications 1, 2 ou 3 dans lequel la surcouche est en verre Schott-Glass®.

6. Elément selon les revendications 1, 2 ou 3 dans lequel le matériau de la surcouche est choisi dans le groupe comprenant SiO_2, MgF_2, SiO, le quartz, la silice et le verre.

7. Procédé d'effacement d'un élément d'enregistrement optique 16 dans lequel les informations sont codées dans des pistes d'enregistrement sous la forme de déformations 46 induites par la chaleur dans une couche d'enregistrement optique 42 déformée par la chaleur;
et dans lequel on applique une chaleur suffisante sur l'élément d'enregistrement pour aplanir les déformations 46 induites par la chaleur formant les pistes d'enregistrement;
procédé caractérisé en ce que ledit élément est un élément selon l'une quelconque des r vendications précédentes;
et en ce qu' n applique la chaleur sélectivement en concentrant un ou plusieurs faisceaux de ray nnement de densité d'énergie élevée — rayonnement qui est absorbé par la couche d'enregistr ment

optique — sur une ou plusiers pistes particulières d'enregistrement ou sur une portion de la ou desdites pistes pour obtenir un effacement au moins partiel.

8. Procédé selon la revendication 7 dans lequel le faisceau de rayonnement de densité d'énergie élevée est un rayon laser qui est tout d'abord concentré sur un bord de la piste d'enregistrement puis sur l'autre bord de la piste d'enregistrement pour aplanir les déformations induites par la chaleur qui forment la piste.

9. Procédé selon la revendication 8 dans lequel un faisceau laser unique est optiquement modulé pour présenter une région de densité d'énergie élevée sur chaque bord de la ou des pistes d'enregistrement.

10. Procédé selon la revendication 7, dans lequel le faisceau laser est concentré sur un bord de la piste d'enregistrement et un autre faisceau laser est concentré sur l'autre bord de la piste d'enregistrement.

11. Procédé selon la revendication 7, dans lequel la piste d'enregistrement ou les portions de piste choisies sont soumises à des expositions répétées de rayon laser pour aplanir les déformations induites par la chaleur formant la piste d'enregistrement.

12. Procédé selon la revendication 7 dans lequel l'impact du faisceau laser sur l'élément est allongé dans la direction de la piste d'enregistrement choisie.

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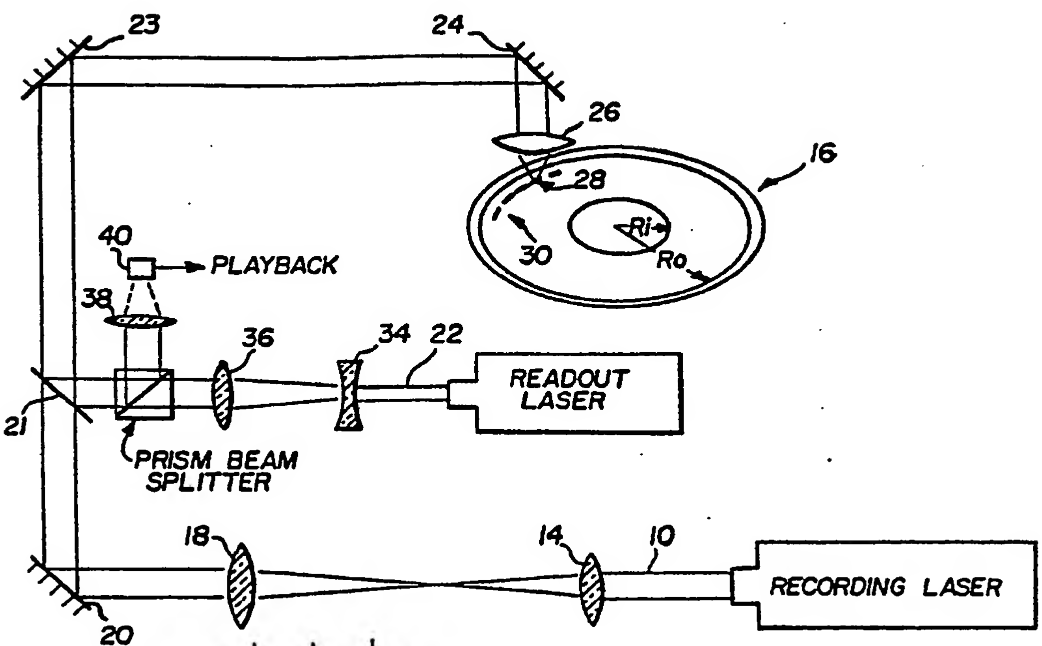

FIG. 1

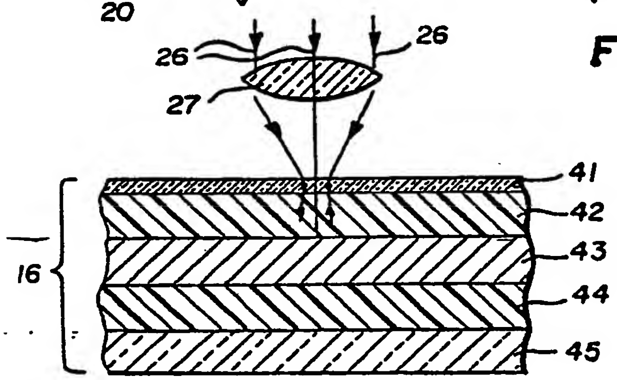

FIG. 2

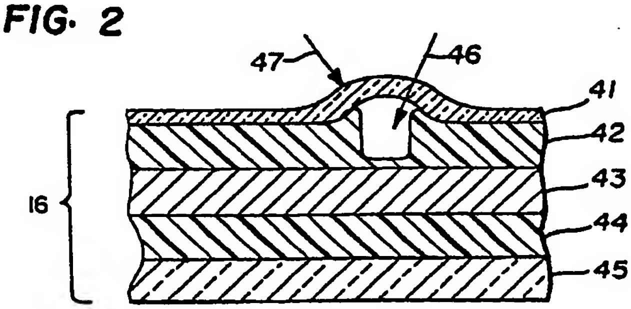

FIG. 3